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COST EFFECTIVENESS OF THREE DIFFERENT
INTERIOR OPEN-TYPE OFFICES

R.M.Dinnat, et al

Army Construction Engineering Research Laboratory
Champaign, Illinois

March 1973

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TECHNICAL REPORT D-2

**COST-EFFECTIVENESS OF THREE DIFFERENT
INTERIOR OPEN-TYPE OFFICES**

by

R.M. Dinnat
Wes Gibbs, Jr.

March 1973

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11. SUPPLEMENTARY NOTES Copies of this report are obtainable from National Technical Information Service, Springfield, Virginia 22151		12. SPONSORING MILITARY ACTIVITY Department of the Army
13. ABSTRACT This report presents an evaluation of three different open-type interior office environments at the U.S. Army Construction Engineering Research Laboratory, Champaign, Ill. The Action office, the GSA Partition office, and the Open Plan office, all containing the same kinds of research activities, were evaluated with respect to cost-effectiveness. Effectiveness was assessed by comparing measures of performance and physical resources among the three offices. Performance was measured indirectly through the occupants' attitudes about their offices. Cost-effectiveness was assessed by comparing the offices' effectiveness ranks with their cost per occupant. Results of the study demonstrated that the Action and Open-Plan offices were more cost-effective than the GSA Partition office. No determination with respect to cost-effectiveness could be made between the Action and Open Plan offices. The Action office provided more effectiveness at a higher cost per occupant; the Open Plan office provided less effectiveness at a lower cost per occupant.		
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FOREWORD

This work was performed under the auspices of the Architecture Branch, Special Projects Division, U.S. Army Construction Engineering Research Laboratory (CERL). Mr. R. W. Cramer was Chief of the Architecture Branch and Dr. R. M. Dinnat was Chief of the Special Projects Division. Colonel R. W. Reisacher and Dr. L. R. Shaffer were Director and Deputy Director, respectively, of CERL.

The authors would like to thank Charles C. Lozar and David Dresse! for the successful performance of the study and A. Osterberg for constructing and administering the questionnaire.

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COST-EFFECTIVENESS OF THREE DIFFERENT INTERIOR OPEN-TYPE OFFICES

1 INTRODUCTION

Background. In January 1970, an expansion of the CERL research staff caused the conversion of open interior laboratory space into office facilities. In order to facilitate both initial conversion to office space and later reconversion to laboratory space, open-type offices were utilized instead of individual offices formed from concrete block partitions. Continued increases in staff, requiring more conversion of laboratory space to office space, provided the opportunity to compare different open-type offices.

Purpose. This study compares the cost-effectiveness of three different open-type offices:

1. Open Plan office (OP)
2. GSA Partition office (GSA)
3. Action office (AO).

Approach. Simply stated, the approach consisted of establishing measures for cost and effectiveness, applying these measures to the offices, and comparing the measurements among offices to determine relative cost-effectiveness.

The dollar was used to measure cost. Since no well-established and accepted measure existed for effectiveness, a measure was developed. Two measures, one for occupant performance and one for office resources, were established and then combined to form a measure of effectiveness.

A typist's performance can be measured by the number of pages typed, but there is no simple measure of a researcher's performance. Since a worker is likely to perform worse when dissatisfied, the researcher's degree of dissatisfaction with his office was selected as an indirect measure of his performance.

A questionnaire was used to determine the degree of each researcher's dissatisfaction with his office. The researcher's ratings were averaged for each office, and the averages were used to rank offices with respect to researcher-dissatisfaction, hence with respect to the average researcher's ability to work therein. Offices were compared with respect to performance by analyzing the rankings to determine if statistically significant differences existed among offices. Where a statisti-

cally significant difference existed, one office was superior to another in performance, i.e., more conducive to work.

Physical characteristics—such as material, size, shape, color and texture—were viewed as resources utilized by the offices to facilitate job performance. Resources differed among offices in two ways: differences in kind (e.g., different colors) and differences in amount (e.g., different floor areas). Those characteristics differing in kind were classified as qualitative resources and those differing in amount as quantitative resources. Since many quantitative measures were already available, only quantitative resources were considered in establishing a measure for office resources; to facilitate data collection, only the spatial measures (length, area and volume) were used.

The performance and resources measures were combined to form a measure of effectiveness. If one office used less of a resource than another office while attaining at least the same level of performance, the office using less was considered more effective.

The measure used for cost-effectiveness was similar to that used for effectiveness. If one office cost less than another office while attaining at least the same level of effectiveness, the office costing less was considered more cost-effective.

Research Plan. The plan consisted of a series of comparisons among the offices:

1. Performance comparison
2. Resources comparison
3. Effectiveness comparison
4. Cost comparison
5. Cost-effectiveness comparison.

A comparison resulted in one of the three following statements about the relative position of two offices with respect to the factor (e.g., performance) compared:

1. The office is superior to another office.
2. The office is inferior to another office.
3. The superior office cannot be determined.

The outputs of the performance and resources

comparisons served as input into the effectiveness comparison and the outputs of the cost and effectiveness comparisons served as input into the cost-effectiveness comparison. Thus the series of comparisons resulted in one of the above three statements about each office relative to each other office with respect to cost-effectiveness.

2 PERFORMANCE COMPARISON

Since dissatisfaction with one's office was the indirect measure of performance, the researchers' attitudes about their offices provided the basic data; the Wilcoxon test for statistically significant differences was the mechanism for the comparison.

Questionnaire. Attitudes were solicited by questionnaire about four different aspects of an office:

1. General conditions
2. Appearance and atmosphere
3. Furniture and equipment
4. Storage space.

For each aspect, potential indicators of dissatisfaction were presented to the occupants. Respondents could choose an appropriate condition along a five-unit semantic scale. Using the factor "roominess," for example, the respondent could choose from: extremely roomy, moderately roomy, neither roomy nor cramped, moderately cramped and extremely cramped.

The complete questionnaire is presented in Tables 1 through 4 along with profiles of the mean responses from each office. The profiles visually summarize how the offices fared relative to one another. Complete survey results are presented in Appendix A. The survey elicited answers from 25 researchers. Of these, 12 were in the Action office, 7 in the GSA Partition office and 6 in the Open Plan office.

Statistics. For this study, it was not considered necessary to test the significant statistical differences among the mean scores for each office on each factor rated in the questionnaire. Instead, the four aspects used in the questionnaire were selected as parameters.

Associated with each parameter (e.g., General Conditions) are several factors rated by the occupants.

Table 1
Semantic Scales and Mean Scores for General Conditions

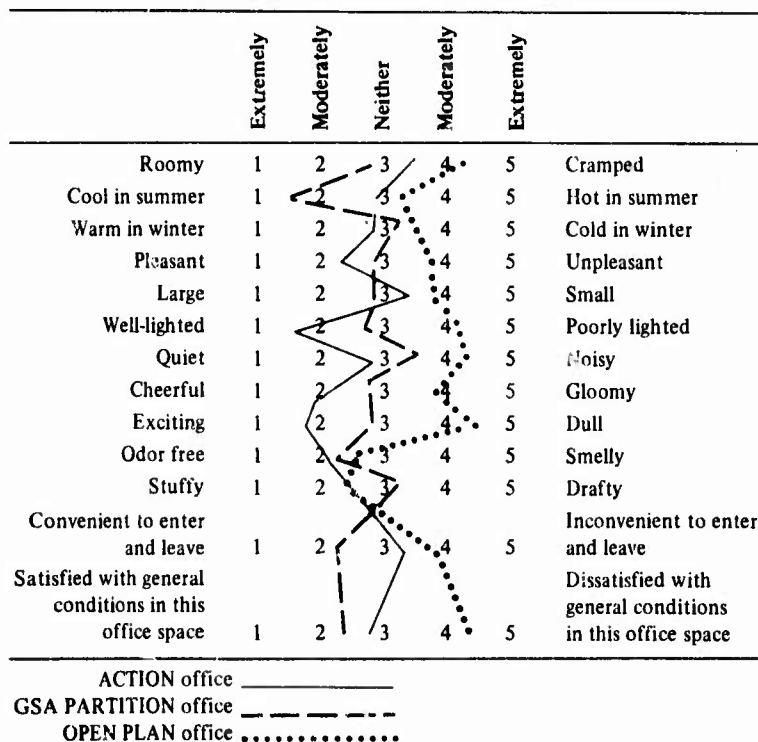


Table 2
Semantic Scales and Mean Scores for Appearance and Atmosphere

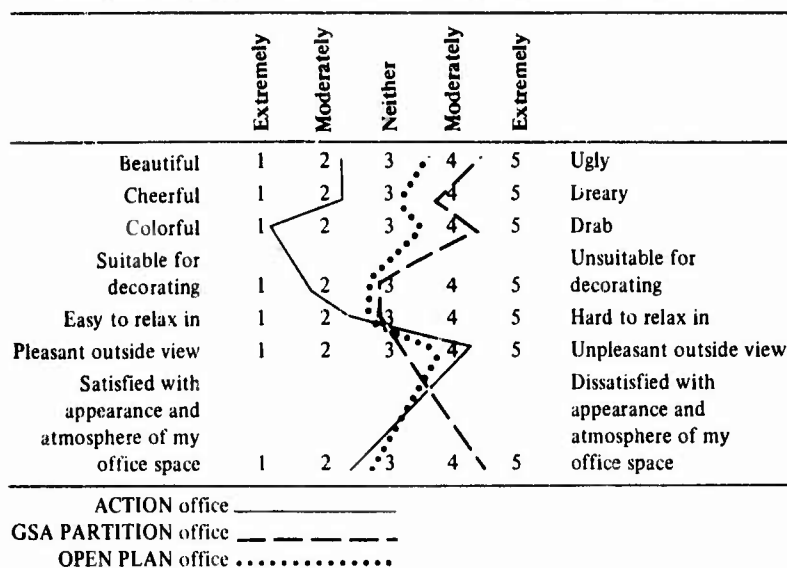
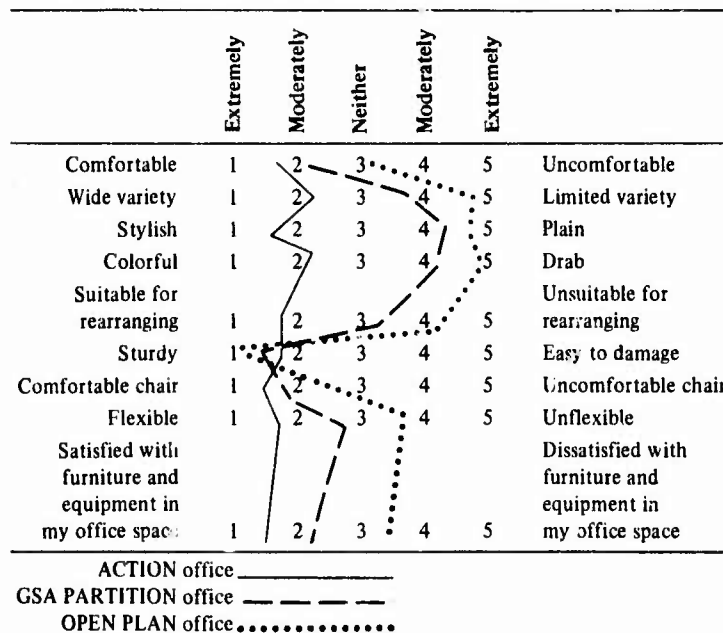


Table 3
Semantic Scales and Mean Scores for Furniture and Equipment



Collectively, these rated factors constitute a performance measure for that parameter. The Wilcoxon test provided a means of determining whether a statistically significant difference existed between factor ratings for two different offices.

The difference in performance between two offices on any factor can be indicated by subtracting their two ratings. In this study, subtracting rating A from rating B resulted in a positive number when A was better than B, a negative number when B was bet-

Table 4
Semantic Scales and Mean Scores for Storage Space

	Extremely	Moderately	Neither	Moderately	Extremely	
Adequate amount of storage space	1	2	3	4	5	Inadequate amount of storage space
Adequate for large personal items (e.g., attache case)	1	2	3	4	5	Inadequate for large personal items
Adequate for small personal items	1	2	3	4	5	Inadequate for small personal items
Easy to keep secure from others	1	2	3	4	5	Hard to keep secure from others
Easy to store items	1	2	3	4	5	Hard to store items
Satisfied with storage space in my work area	1	2	3	4	5	Dissatisfied with storage space in my work area

ACTION office _____
 GSA PARTITION office, — — — — —
 OPEN PLAN office,

ter than A, and zero when they were equal. Corresponding to each parameter, then, was a series of positive and/or negative numbers—one for each associated factor.

If there were no significant difference between offices, one would expect the positive and negative numbers to be nearly equally divided. If one office were better, a preponderance of either positive or negative numbers would be expected. Starting with these statements, the Wilcoxon test permitted the computation of a probability that a significant difference in performance existed between offices. The computations are provided in Appendix B.

Basis of Comparison. One office was considered to be superior to another if the Wilcoxon test showed at least a 95 percent probability that a significant difference existed.

Results of Comparison. Table 5 presents the results of comparing offices with respect to performance on each of the four selected parameters. The column headings indicate the offices being compared and the order of comparison. A positive sign in a column indicates that the office listed first in the heading is superior (more conducive to work) to the office listed second; a negative sign indicates the opposite. A zero in a column indicates that neither office could be considered superior.

3 RESOURCE COMPARISON

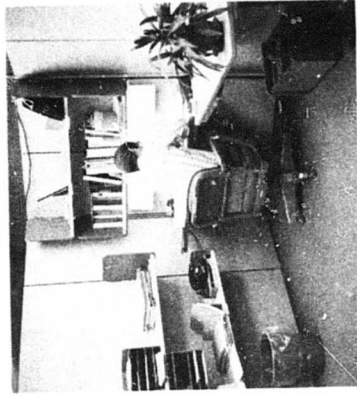
The physical characteristics of an office, qualitative as well as quantitative, make up its resources. Although only quantitative characteristics are used in the resource comparison, qualitative characteristics are presented for information. Also included are photographs and floor plans of the three offices.

Qualitative Resources. Figure 1 provides photographs of the three offices. For each office a general view of the space and a typical work station are shown. Figure 2 presents floor plans of the offices, including furniture and equipment arrangements. Table 6 summarizes the major qualitative physical characteristics of the three offices.

Quantitative Resources. All quantitative office characteristics used in this study are spatial. A researcher's performance was considered to be affected by the available amount of each characteristic. Table 7 lists the selected quantitative resources and summarizes the amounts in each office.

Basis of Comparison. In keeping with the concept that physical characteristics are resources, one office ranks higher than another if it utilizes (has) a smaller amount of a physical resource.

Action Office



Open Plan Office



GSA Partition Office

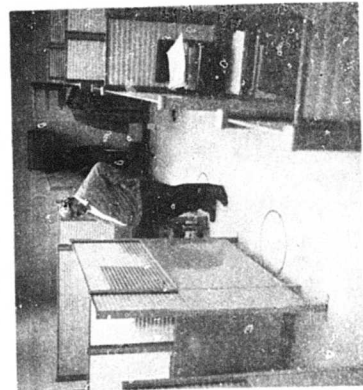
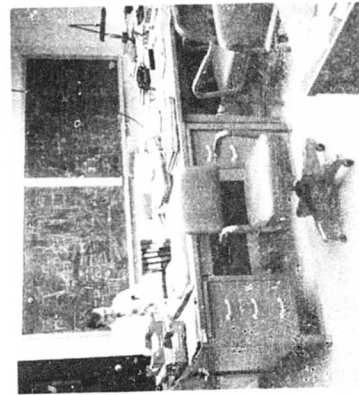
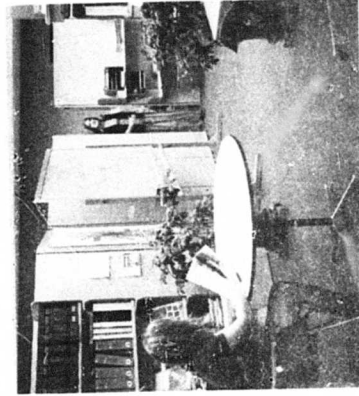
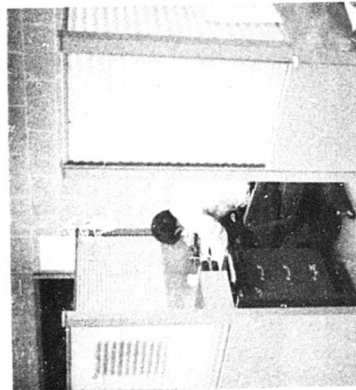
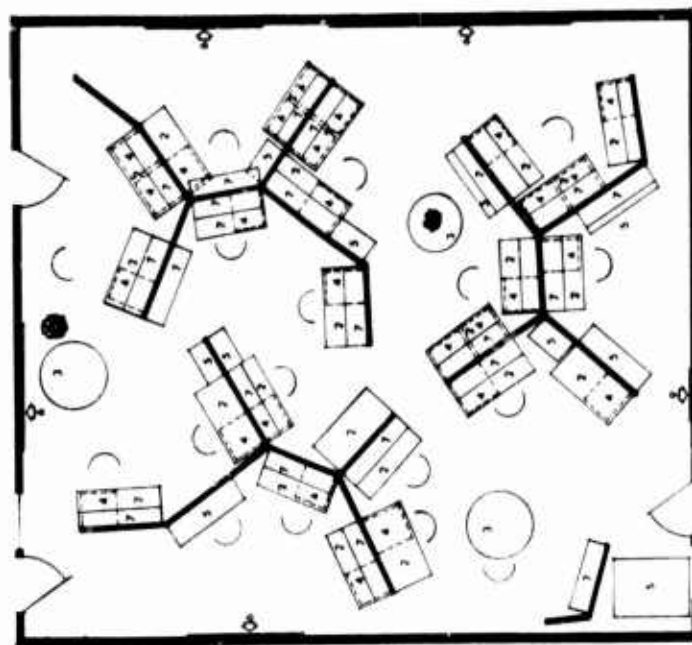
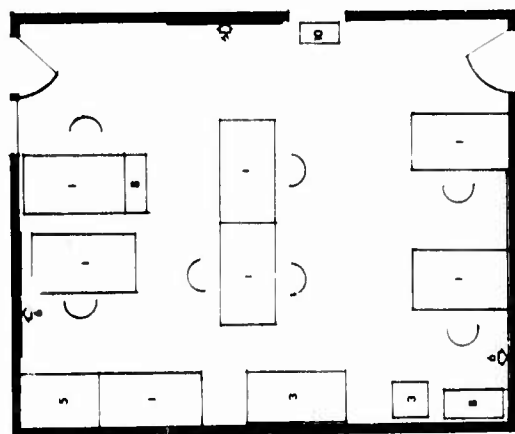


Figure 1. Overview and work station photographs of each office.

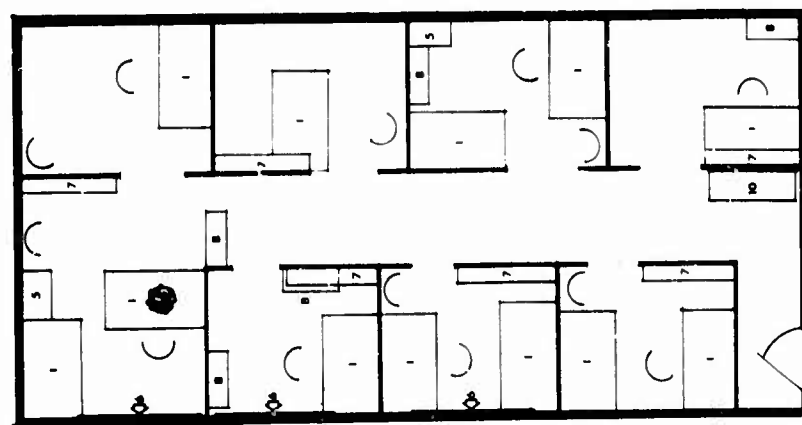


ACTION OFFICE



OPEN PLAN

LEGEND	
1	DESK
2	WORK SURFACE
3	TABLE
4	WORK SURFACE DRAWER
5	FILES
6	BLACKBOARD
7	SHelves
8	BOOKCASE
9	COAT BOARD
10	COAT RACK



GSA PARTITION OFFICE

Figure 2. Office Plans.

Table 5
Performance Table*

Office Parameters	AO:OP	AO:GSA	GSA:OP
1. General Conditions	+	0	0
2. Appearance/Atmosphere	+	+	0
3. Furniture/Equipment	+	+	0
4. Storage Space	+	0	+

*How to read table:

In column AO:OP, if sign is

+ read: Action office is superior in performance to the Open Plan office.

- read: Action office is inferior in performance to the Open Plan office.

0 read: Action office is same in performance as the Open Plan office.

Table 6
Qualitative Resources

Physical Characteristics	Action Office	G.S.A. Partition Office	Open Plan Office
Color:			
Walls	Light olive	Light olive	Light olive
Flooring	Red-orange	Off-white	Off-white
Partitions	Light gray-tan	Eye-ease green	None
Ceiling	White	White	White
Lighting:			
General	Fluor.	Fluor.	Fluor.
Workspace	Fluor.	None	None
Ceiling:	Acoustical tile and glass light-diffusers		
Walls:	Painted concrete block		
Flooring:	Carpet	Vinyl tile	Vinyl tile
Partitions:	*Herman Miller	GSA catalogue	None
Furniture:	Action Office II	GSA catalogue	GSA catalogue

* Further information is available from Herman Miller, Inc., Zeeland, Michigan.

Results of Comparison. Table 8 compares the selected physical characteristics of each office. As with Table 5, the column headings indicate the offices being compared and the order of comparison. Each number in a column is the amount of difference in a resource between the two offices compared. The sign on each number indicates whether the office listed first in the column heading had more (or less) of the resource than the office listed second. A positive sign indicates more; a negative sign indicates less. A positive sign also indicates that the office listed second ranks higher than the office listed first since it would utilize less of the resource, and vice-versa for a negative sign.

4 EFFECTIVENESS COMPARISON

Effectiveness is the combined effect of performance and resources. Since the performance and resource comparisons each resulted in rankings for several different factors, a scoring scheme was devised to combine groups of ranked factors into a single ranking. Single rankings were used in making the effectiveness comparison.

Scoring Scheme. A point system was established for converting ranked factors into a single ranking. On each factor an office was awarded points as follows:

1. If superior to both of the other offices. . . .2 pts
2. If superior to one of the other offices. . . .1 pt
3. Otherwise.0 pts

The sum of the points acquired on each factor constituted an office's score. Between two offices, the office with the higher score was superior. Tables 9 and 10 display the results of the scoring procedure for performance and resources respectively. A quick glance at the tables shows the Action office to be vastly superior in performance score, although not greatly superior in resources score, and better than both other offices on four of the six factors considered.

Basis of Comparison. An ideal effectiveness comparison occurs when performance and resources are measured on ratio scales with the same unit of measure. The ratio of performance to resources then determines whether the amount of performance received is equal to or greater than the amount of resources used. Also, the relative effectiveness of two offices can be determined by comparing their ratios—the higher the ratio, the more effective the office.

Ratio scales with the same unit of measure could not be utilized in this case; only ordinal scales were plausible. Consequently, the superiority of one office over another could not be determined in all cases. Superior performance with equal or less resources or equal performance with less resources definitely results in greater effectiveness, but superior performance with more resources or inferior performance with less resources provides no logical basis for determining greater effectiveness.

Table 11 shows all possible outcomes for ordinal scales when comparing the performance and resources of two offices to determine their relative effectiveness. Each column represents a possible situation between any two offices A and B. A plus sign indicates that office A is superior, a minus sign that office B is superior.

Table 7
Quantitative Resources

Physical Characteristics	Action Office	GSA Partition Office	Open Plan Office	Measure
1. Floor Space	79.0	102.9	83.3	ft ² /person
2. Partitions	49.6	60.0	0	ft ² /person
3. Blackboard Space	13.5	10.3	28.0	ft ² /person
4. Work Surface	14.8	32.4	16.5	ft ² /person
5. Drawer Space	0.8	5.0	5.1	ft ³ /person
6. File Space	2.6	6.8	2.2	ft ³ /person
7. Shelf Space	12.1	14.9	14.4	ft ² /person

Table 8
Resources Table*

Quantitative Characteristics	AO:OP	AO:GSA	GSA:OP	Measure
1. Floor Space	-4.3	-23.8	+19.5	ft ² /person
2. Partitions	+49.6	-10.5	+60.0	ft ² /person
3. Blackboard Space	-14.5	+3.2	-17.7	ft ² /person
4. Work Surface	-1.8	-17.6	+15.9	ft ² /person
5. Drawer Space	-4.3	-4.2	-0.1	ft ³ /person
6. File Space	+0.4	-4.2	+4.7	ft ³ /person
7. Shelf Space	-2.3	-2.8	+0.5	ft ² /person

How to read table:

In column AO:OP, if sign is

+ read: Action office has more than Open Plan office by amount shown.

- read: Action office has less than Open Plan office by amount shown.

Table 9
Scoring Table for Performance (4 factors)

Comparisons	Number of Occurrences			Points Per Occurrence	Number of Points		
	AO	GSA	OP		AO	GSA	OP
Better than both	2	0	0	2	4	0	0
Better than one	2	1	0	1	2	1	0
Indeterminate	0	3	4	0	0	0	0
Performance Score (Sum)					6	1	0
Office Ranking					1	2	3

Table 10
Scoring Table for Resources (7 factors)

Comparisons	Number of Occurrences			Points Per Occurrence	Number of Points		
	AO	GSA	OP		AO	GSA	OP
Better than both	4	1	2	2	8	2	4
Better than one	3	1	3	1	3	1	3
Indeterminate	0	0	0	0	0	0	0
Resources Score (Sum)					11	3	7
Office Ranking					1	3	2

Table 11
Comparison Table : Effectiveness*

	A:B	A:B	A:B	A:B	A:B	A:B	A:B	A:B	A:B
Performance	+	+	+	0	0	0	-	-	-
Resources	+	0	-	+	0	-	+	0	-
Effectiveness	0	+	+	-	0	+	-	-	0

How to read table:

In first column if performance of office A is superior (+) to performance of office B and resources of office A are greater (+) than resources of office B, then effectiveness of office A relative to office B is indeterminate (0).

Table 12
Effectiveness Table*

	AO:OP	AO:GSA	GSA:OP
Performance	+	+	+
Resources	-	-	+
Effectiveness	+	+	0

How to read table:

In column AO:OP if sign is

+ read: Performance—Action office is superior to Open Plan office. Resources—Action office has more than Open Plan office. Effectiveness—Action office is superior to Open Plan office.

- read: Performance—Action office is inferior to Open Plan office. Resources—Action office has less than Open Plan office. Effectiveness—Action office is inferior to Open Plan office.

0 read: Action office same as Open Plan office.

or, and a zero that the superior office cannot be determined.

Results. Table 12 summarizes the results of the comparison. As in previous tables, plus indicates that the first listed office is superior, minus indicates that the second listed office is superior, and zero indicates that superiority cannot be determined. The signs for performance and resources were determined from the rankings in Tables 9 and 10. The signs for effectiveness were then determined from Table 11.

A glance at Table 12 reveals that the Action office is more effective than both the other offices, while the relative effectiveness of the GSA Partition office and the Open Plan office cannot be determined.

5 COST COMPARISON

Since there was considerable variation in office size and furnishing, the total cost for each office was averaged over the number of occupants in order to arrive at a uniform measure (cost per office space) for the comparison.

Compilation of Costs. Prior to their conversion to office space, each interior lab space had essentially the same physical characteristics. The costs used in this study were those required to convert the existing open space into office space. These costs are summarized in Table 13.

Basis of Comparison. As might be expected, one open-type office ranks higher than another if its cost per office space is less.

Results. Table 14 summarizes the cost comparison. The cost per office space was greatest for the GSA Partition office, less for the Action office, and least for the Open Plan office. The modification costs per person were computed from Table 13. The floor-space costs per person came from the actual construction cost per square foot (\$25) and the floor-space determinations of Table 7. The cost per office space was obtained by adding the modification and floor-space costs, and the rankings came from applying the basis of comparison.

Other Comparisons. New construction and leasing are situations in which a cost comparison of different open-type offices might be desirable.

In a new construction situation most of the "other costs" in Table 13 would be included in the initial construction costs; partitioning is the exception. Since in the Action office the partitions and furniture are part of the same unit, the labor for erecting partitions was considered as part of the furnishings cost in the cost comparison for new construction. The results are summarized in Table 15. A comparison between Tables 14 and 15 shows that no change in ranking occurred. However, the Action office would have cost less if it had been part of the original construction plan.

In a leasing situation, the additional cost expended for improved performance may be viewed as recoverable. For this to happen, the office space with the

Table 13
Modification Costs

Items Included*	Action Office (13 persons)	GSA Partition Office (8 persons)	Open Plan Office (7 persons)
Furniture/Equipment			
Partitions	X	X	
Desks and chairs	X	X	X
Filing cabinets	X	X	X
Tables	X	X	X
Bookcases	X	X	X
Shelves	X	X	X
Desk lights	X		
Metal bookends	X		
Other			
Carpet	X		
Labor: Carpeting	X		
Wiring	X		
Partitioning	X	X	
Cost of furniture/equipment	\$5440	\$2288	\$1032
Other costs	\$2100	\$ 600	0
Total Costs	\$7540	\$2888	\$1032

* If an X appears in a column opposite an item, at least one such item was included in the total modification costs of that office.

Table 14
Modification Cost Comparison

	Action Office	GSA Partition Office	Open Plan Office
Modification costs per person	\$ 580	\$ 361	\$ 148
Floor space costs per person	1975	2573	2083
Costs per office space (sum)	\$2555	\$2934	\$2231
Rank of office	2	3	1

Table 15
New Construction Cost Comparison

	Action Office	GSA Partition Office	Open Plan Office
New construction costs per person	\$ 457	\$ 361	\$ 148
Floor space costs per person	1975	2573	2083
Costs per office space (sum)	\$2432	\$2934	\$2231
Rank of office	2	3	1

more expensive furnishings must be superior in performance and have less square footage. Less square footage in an office space means the rental cost is less, and the savings can be thought of as payments on the additional cost of the more expensive furnishings.

Furnishings in the Action office cost \$432 more per office space than in the Open Plan office, and the square footage is 4.3 less. The present rent is \$3.43 per square foot per year; therefore, an Action office space saves \$14.75 per year. In terms of constant dollars, it will take 29.3 years to recover the extra expense of an Action office space.

6 COST-EFFECTIVENESS COMPARISON

As was the case with the effectiveness comparison, the information used in this comparison had different units of measure and was ordinal in nature; consequently, it has the same limitations as the effectiveness comparison.

Basis of Comparison. The basis for comparing cost-effectiveness between two offices is directly analogous to the basis used to compare effectiveness, except cost and effectiveness replace performance and resources. Table 16 shows all possible outcomes when comparing

Table 16
Comparison Table: Cost Effectiveness*

	A:B	A:B	A:B	A:B	A:B	A:B	A:B	A:B	A:B
Effectiveness	+	+	+	0	0	0	-	-	-
Cost	+	0	-	+	0	-	+	0	-
Cost-Effectiveness	0	+	+	-	0	+	-	-	0

How to read table:

In first column if sign is

+ read: Effectiveness—Action office is superior to Open Plan office. Cost—Action office is more than Open Plan office. Cost-Effectiveness—Action office is superior to Open Plan office.

- read: Effectiveness—Action office is inferior to Open Plan office. Resources—Action office has less than Open Plan office. Cost-Effectiveness—Action office is inferior to Open Plan office.

0 read: Action office same as Open Plan office.

Table 17
Cost-Effectiveness Table*

	AO:OP	AO:GSA	GSA:OP
Cost per person	+	-	+
Effectiveness	+	+	0
Cost-Effectiveness	0	+	-

How to read table:

In column AO:OP if sign is

+ read: Cost Per Person—Action office is superior to Open Plan office. Effectiveness—Action office has more than Open Plan office. Cost-Effectiveness—Action office is superior to Open Plan office.

- read: Cost Per Person—Action office is inferior to Open Plan office. Effectiveness—Action office has less than Open Plan office. Cost-Effectiveness—Action office is inferior to Open Plan office.

0 read: Action office same as Open Plan office.

the cost and effectiveness of two offices to determine their relative cost-effectiveness. As before, a plus sign indicates that office A is superior, a minus sign that office B is superior, and a zero that the superior office cannot be determined.

Results. Table 17 summarizes the comparison. Again, plus indicates that the first listed office is superior, minus that the second listed office is superior, and zero that superiority cannot be determined. The signs for cost and effectiveness were determined from the rankings in Tables 14 and from Table 15. The signs for cost-effectiveness were then obtained from Table 16. As shown in Table 17 both the Action and Open Plan offices are more cost-effective than the GSA Partition office. The relative cost-effectiveness of the Action and Open Plan offices could not be determined logically.

Other Comparisons. New construction and leasing are situations in which a cost-effectiveness comparison might be desirable. The cost rankings for new construction, shown in Table 16, are the same as those used in the cost-effectiveness comparison described above. Consequently, the results of the cost-effectiveness comparison for new construction do not differ from those of the previous section.

The Action office would be more cost-effective than the Open Plan office in a leasing situation if the additional expense could be recovered within the expected life of the modifications. Since the usual life expectancy for furniture is 10 years and the time required to recover the money is 29.3 years, the results of the previous section are also true for the leasing situation.

Commentary. The inability to establish the relative cost-effectiveness of the Action and Open Plan offices resulted from the nature of the experimental data and indicates the undeveloped state of the art in this area. Any choice between these two offices must therefore be based on whether the increase in effectiveness is worth the additional cost.

Leased office space proves a basis for choosing between the Action and Open Plan offices. Because the Action office had less square footage per office space, the rent saved could be viewed as payment on the extra initial cost of the Action office furnishings. If the additional cost could have been recovered within the expected life of the furnishings, the Action office would have been considered more cost-effective. It should be noted that this approach does not determine whether increase in effectiveness is worth the additional cost, but simply whether an additional cost actually occurs.

7 CONCLUSIONS

Using the researcher's degree of dissatisfaction with his office as an indirect measure of his ability to work therein:

1. The Action office is more conducive to work than either the GSA Partition or the Open Plan office. It is considerably superior to the Open Plan office, less so with respect to the GSA Partition office.
2. The GSA Partition office is slightly more conducive to work than the Open Plan office.

Using floor space, partitions, blackboard space, work surface, drawer space, file space and shelf space as resources:

1. The Action office requires less resources than the other two offices in most categories while being more conducive to work.
2. With the exception of the partition category, the amounts by which the resources of the

Action office exceed the other offices are relatively small; consequently, the Action office would very likely maintain its superior conduciveness to work even if the resources in such categories were equal.

Defining effectiveness as the resources required to achieve a given level of conduciveness-to-work:

1. The Action office is more effective than both the GSA Partition office and the Open Plan office.
2. Whether the GSA Partition office was more effective than the Open Plan office could not be determined.

Defining cost-effectiveness as the cost required to achieve a given level of effectiveness:

1. Both the Action office and the Open Plan office were more cost-effective than the GSA Partition office.
2. Whether the Action office was more cost-effective than the Open Plan office could not be determined.

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APPENDIX A: FREQUENCY OF RESPONSES

The following tables (A-1-A-4) present the frequency of responses for each item of the four categories of the performance measures referenced in Chapter 1 of the report.

Table A-1
General Conditions

		1	2	3	4	5	
Roomy	AO	3	1	3	5		Cramped
	GSA	2	3	2			
	OP		1	3	2		
Cool in summer	AO	1	5	3	2	1	Hot in summer
	GSA	3	3	1			
	OP		2	2	1		
Warm in winter	AO	1	2	5			Cold in winter
	GSA		4		2	1	
	OP			2	2		
Pleasant	AO	2	7	1	1	1	Unpleasant
	GSA	1	2	1	3		
	OP		1		3	2	
Large	AO		5		4	3	Small
	GSA			5	1	1	
	OP			3	1	2	
Well-lighted	AO	5	5			2	Poorly lighted
	GSA	1	4	1		1	
	OP		1		3	2	
Quiet	AO		3	4	5		Noisy
	GSA			1	4	2	
	OP				3	3	
Cheerful	AO	2	6	4			Gloomy
	GSA		3	2		2	
	OP		1	2	1	2	
Exciting	AO	2	8	2			Dull
	GSA	1	1	3	1	1	
	OP			2	1	3	
Odor free	AO	6	2	4			Smelly
	GSA	1	5		1		
	OP	2	2	1		1	
Stuffy	AO		4	8			Drafty
	GSA	1	2	2	1	1	
	OP	1	1	3			
Convenient to enter and leave	AO	2	2	1	4	3	Inconvenient to enter and leave
	GSA		4	1	2		
	OP		1	1	2	2	

Table A-2
Appearance and Atmosphere

		1	2	3	4	5	
Beautiful	AO	3	5	3	1		Ugly
	GSA		1	2	4		
	OP			1	3	2	
Cheerful	AO	2	8	2			Dreary
	GSA		3	1	2	1	
	OP		1	1	1	3	
Colorful	AO	3	9				Drab
	GSA		1	2	3	1	
	OP			1	2	3	
Suitable for decorating	AO	1	9	1	1		Unsuitable for decorating
	GSA	1	2	2	2		
	OP	1	2	1	2		
Easy to relax in	AO	4	3	3	2		Hard to relax in
	GSA	1	3	2		1	
	OP		2	1	2	1	
Pleasant outside view	AO		1	4	1	3	Unpleasant outside view
	GSA			2	1	3	
	OP			2		4	

Table A-3
Furniture and Equipment

		1	2	3	4	5	
Comfortable	AO	6	4	2			Uncomfortable
	GSA		5	2			
	OP		2	3	1		
Wide variety	AO	2	8	2			Limited variety
	GSA		1	1	4	1	
	OP				1	5	
Stylish	AO	5	4	3			Plain
	GSA				3	4	
	OP			1	1	4	
Colorful	AO	1	6	3	2		Drab
	GSA				4	3	
	OP				1	5	
Suitable for rearranging	AO	7	2	1	2		Unsuitable for rearranging
	GSA		1	2	4		
	OP			2	2	2	
Sturdy	AO	4	7	1			Easy to damage
	GSA	5	2				
	OP	6					
Comfortable chair	AO	6	4		1	1	Uncomfortable chair
	GSA	1	5	1			
	OP		4	1		1	
Flexible	AO	4	6	2			Unflexible
	GSA	1	1	4	1		
	OP		1		3	2	

Table A-4
Storage Space

		1	2	3	4	5	
Adequate amount	AO	2	4		2	4	Inadequate amount
	GSA		3	1	3		
	OP		1		1	4	
Adequate for large personal items	AO	3	1	2	3	3	Inadequate for large personal items
	GSA	1	2	3	1		
	OP				2	4	
Adequate for small personal items	AO	3	1	4	3	1	Inadequate for small personal items
	GSA	2	4	1			
	OP		2	1	2	1	
Easy to keep secure from others	AO	1	3	3	2	3	Hard to keep secure from others
	GSA		1	3	1	2	
	OP		1	2	1	2	
Easy to store items	AO	3	3		3	3	Hard to store items
	GSA	1	3	1	1		
	OP		2	2	2		

APPENDIX B: SUMMARY OF WILCOXEN TEST COMPUTATIONS

The following tables (B-1–B-12) present the calculations and results of the Wilcoxon Matched-Pairs Signed-Rank Tests for each of the four categories of measures referenced in Chapter 2.

Table B-1					
Action Office vs. Open Plan Office—General Conditions of Office Space					
RESULTS: $T = 4$; $N = 13$; $P < .01$					
Action office significantly better than Open Plan office.					
General Conditions	Mean Rating Action Office	Mean Rating Open Plan Office	Difference in Ratings	Rank of Difference	Negative Ranks
Roomy – Cramped	3.92	4.14	+ .22	2	
Cool in summer – Warm in summer	2.54	3.40	+ .86	7	
Warm in winter – Cold in winter	2.90	3.00	+ .10	1	
Pleasant – Unpleasant	2.42	4.00	+1.58	10	
Large – Small	3.41	3.83	+ .42	5	
Well-lighted – Poorly lighted	1.75	4.00	+2.75	13	
Quiet – Noisy	3.16	4.33	+1.17	8	
Cheerful – Gloomy	1.75	3.66	+1.91	11	
Exciting – Dull	2.00	4.16	+2.16	12	
Odor free – Smelly	2.00	2.33	+ .33	3	
Stuffy – Drafty	2.75	2.40	– .35	4	4
Convenient to enter – Inconvenient	3.08	3.83	+ .75	6	
Satisfied – Dissatisfied	2.83	4.33	+1.50	9	

Table B-2					
Action Office vs. GSA Partition Office—General Conditions of Office Space					
RESULTS: $T = 31.5$; $N = 13$					
No significant difference; Action office same as GSA Partition office.					
General Conditions	Action Office	GSA Partitions Office	Difference	Rank of Difference	Negative Ranks
Roomy – Cramped	3.92	2.83	–1.09	11	11
Cool in summer – Warm in summer	2.54	1.71	–.83	9	9
Warm in winter – Cool in winter	2.90	3.16	+ .26	12	
Pleasant – Unpleasant	2.42	2.71	+ .29	2	
Large – Small	3.41	3.00	–.41	4.5	4.5
Well-lighted – Poorly lighted	1.75	3.00	+1.25	13	
Quiet – Noisy	3.16	3.66	+ .50	7	
Cheerful – Gloomy	1.75	2.83	+1.08	10	
Exciting – Dull	2.00	2.66	+ .66	8	
Odor free – Smelly,	2.00	2.33	+ .33	3	
Stuffy – Drafty	2.75	3.16	+ .41	4.5	
Convenient to enter – Inconvenient	3.08	2.66	–.42	6	6
Satisfied – Dissatisfied	2.83	2.66	–.17	1	1

Table B-3
GSA Partition Office vs. Open Plan Office—General Conditions of Office Space

RESULTS: T = 6; N = 13

No significant difference; GSA Partition office same as Open Plan office.

General Conditions	GSA Partitions Office	Open Plan Office	Difference	Rank of Difference	Negative Ranks
Roomy - Cramped	2.83	4.14	+1.31	10	
Cool in summer - Warm in summer	1.71	3.40	+1.69	13	
Warm in winter - Cool in winter	3.16	3.00	-.16	2	2
Pleasant - Unpleasant	2.71	4.00	+1.29	9	
Large - Small	3.00	3.83	+.83	5.5	
Well-lighted - Poorly lighted	3.00	4.00	+1.00	7	
Quiet - Noisy	3.66	4.33	+.67	3	
Cheerful - Gloomy	2.83	3.66	+.83	5.5	
Exciting - Dull	2.66	4.16	+1.50	11	
Odor free - Smelly	2.33	2.33	0	1	
Stuffy - Drafty	3.16	2.40	-.76	4	4
Convenient to enter - Inconvenient	2.66	3.83	+1.17	8	
Satisfied - Dissatisfied	2.66	4.33	+1.67	12	

Table B-4
Action Office vs. Open Plan Office—Appearance and Atmosphere

RESULTS: T = 0; N = 6; p < .05

Action office significantly better than Open Plan office.

Appearance and Atmosphere	Action Office	Open Plan Office	Difference	Rank of Difference	Negative Ranks
Beautiful - Ugly	2.00	4.16	+2.16	5	
Cheerful - Dreary	2.08	4.00	+1.98	4	
Colorful - Drab	1.75	4.33	+2.58	6	
Suitable for decoration - Unsuitable	1.92	2.66	+.74	1	
Easy to relax in - Hard	2.58	3.33	+.75	2	
Satisfied - Dissatisfied	2.66	4.16	+1.50	3	

Table B-5
Action Office vs. GSA Partition Office—Appearance and Atmosphere

RESULTS: T = 0; N = 6; p < .05

Action office significantly better than GSA Partition office.

Appearance and Atmosphere	Action Office	Open Plan Office	Difference	Rank of Difference	Negative Ranks
Beautiful - Ugly	2.00	3.42	+1.42	5	
Cheerful - Dreary	2.08	3.14	+1.06	5	
Colorful - Drab	1.75	3.37	+1.62	6	
Suitable for decoration - Unsuitable	1.92	3.16	+1.24	4	
Easy to relax in - Hard	2.58	3.00	+.42	1	
Satisfied - Dissatisfied	2.66	3.16	+.50	2	

Table B-6
GSA Partition Office vs. Open Plan Office—Appearance and Atmosphere

RESULTS: T = 2; N = 6					
No significant difference; GSA Partition office same as Open Plan office.					
Appearance and Atmosphere	Action Office	Open Plan Office	Difference	Rank of Difference	Negative Ranks
Beautiful – Ugly	3.42	4.16	+ .74	3	
Cheerful – Dreary	3.14	4.00	+ .86	4	
Colorful – Drab	3.37	4.33	+ .96	5	
Suitable for decoration—Unsuitable	3.16	2.66	– .50	2	2
Easy to relax in – Hard	3.00	3.33	+ .33	1	
Satisfied – Dissatisfied	3.16	4.16	+1.00	6	

Table B-7
Action Office vs. Open Plan Office—Furniture and Equipment

RESULTS: T = 1.5; N = 8; p < .02					
Action office significantly better than Open Plan office.					
Furniture and Equipment	Action Office	Open Plan Office	Difference	Rank of Difference	Negative Ranks
Comfortable – Uncomfortable	1.83	3.00	+1.17	3	
Wide variety – Limited	2.17	4.83	+2.66	3	
Stylish – Plain	1.83	4.50	+2.67	8	
Colorful – Drab	2.50	4.83	+2.33	6	
Sturdy – Easy to damage	1.75	1.00	– .75	1.5	1.5
Comfortable chair – Uncomfortable	1.92	4.17	+2.25	5	

Table B-8
GSA Partition Office vs. Open Plan office – Furniture and Equipment

RESULTS: T = 11.0; N = 8					
No significant difference; GSA Partition office same as Open Plan office.					
Furniture and Equipment	GSA Partition Office	Open Plan Office	Difference	Rank of Difference	Negative Ranks
Comfortable – Uncomfortable	2.29	3.00	+ .71	4	
Wide variety – Limited	3.71	4.83	+1.12	6	
Stylish – Plain	4.57	4.50	– .07	2	2
Sturdy – Easy to damage	2.14	4.83	+2.69	8	
Comfortable chair – Uncomfortable	2.00	1.00	–1.00	5	5
Flexible – Unflexible	2.71	2.67	– .04	1	1
Colorful – Drab	4.43	4.00	– .43	3	3
Satisfied – Dissatisfied	2.29	4.17	+1.88	7	

Table B-9
Action Office vs. GSA Partition Office—Furniture and Equipment

RESULTS: T = 0; N = 8; p < .01					
Action office significantly better than GSA office.					
Furniture and Equipment	Action Office	GSA Partition Office	Differences	Rank of Difference	Negative Ranks
Comfortable – Uncomfortable	1.82	2.29	+ .47	4	
Wide variety – Limited	2.17	3.71	+1.54	6	
Stylish – Plain	1.83	4.57	+2.74	8	
Sturdy – Easy to damage	1.75	2.14	+ .39	3	
Comfortable chair – Uncomfortable	1.92	2.00	+ .08	1	
Flexible – Unflexible	1.83	2.71	+ .88	5	
Colorful – Drab	2.50	4.43	+1.93	7	
Satisfied – Dissatisfied	1.92	2.29	+ .37	2	

Table B-10
GSA Partition Office vs. Open Plan Office—Storage Space in Work Area

RESULTS: T = 0; N = 6; p < .05					
GSA Partition significantly better than Open Plan office.					
Storage Space in Work Area	Action Office	GSA Partition Office	Differences	Rank of Difference	Negative Ranks
Adequate amount of storage -- Inadequate	3.00	4.33	+1.33	2	
Adequate for large personal items – Inadequate	2.57	4.67	+2.10	6	
Adequate for small personal items – Inadequate	1.86	3.33	+1.47	3	
Easy to keep secure – Hard	3.57	3.67	+ .10	1	
Easy to store items – Hard	2.33	4.00	+1.67	4	
Satisfied – Dissatisfied	2.43	4.33	+1.90	5	

Table B-11
Action Office vs. Open Plan Office—Storage Space in Work Area

RESULTS: T = 0; N = 6; p < .05					
Action office significantly better than Open Plan office.					
Storage Space in Work Area	Action Office	GSA Partition Office	Differences	Rank of Differences	Negative Ranks
Adequate amount of storage —					
Inadequate	3.17	4.33	+1.16	5	
Adequate for large personal items	3.17	4.67	+1.50	6	
Adequate for small personal items	2.83	3.33	+ .50	2	
Easy to keep secure — Hard	3.25	3.67	+ .42	1	
Easy to store items — Hard	3.00	4.00	+1.00	4	
Satisfied — Dissatisfied	3.42	4.33	+ .91	3	

Table B-12
Action Office vs. GSA Partition Office—Storage Space in Work Area

RESULTS: T = 2; N = 6					
No significant difference; Action office same as GSA Partition office.					
Storage Space in Work Area	Action Office	GSA Partition Office	Differences	Rank of Difference	Negative Ranks
Adequate amount of storage —					
Inadequate	3.17	3.00	+.17	1	
Adequate for large personal items	3.17	2.57	+.60	3	
Adequate for small personal items	2.83	1.86	+.97	5	
Easy to keep secure — Hard	3.25	3.57	-.32	2	2
Easy to store items — Hard	3.00	2.33	+.67	4	
Satisfied — Dissatisfied	3.42	2.43	+.99	6	